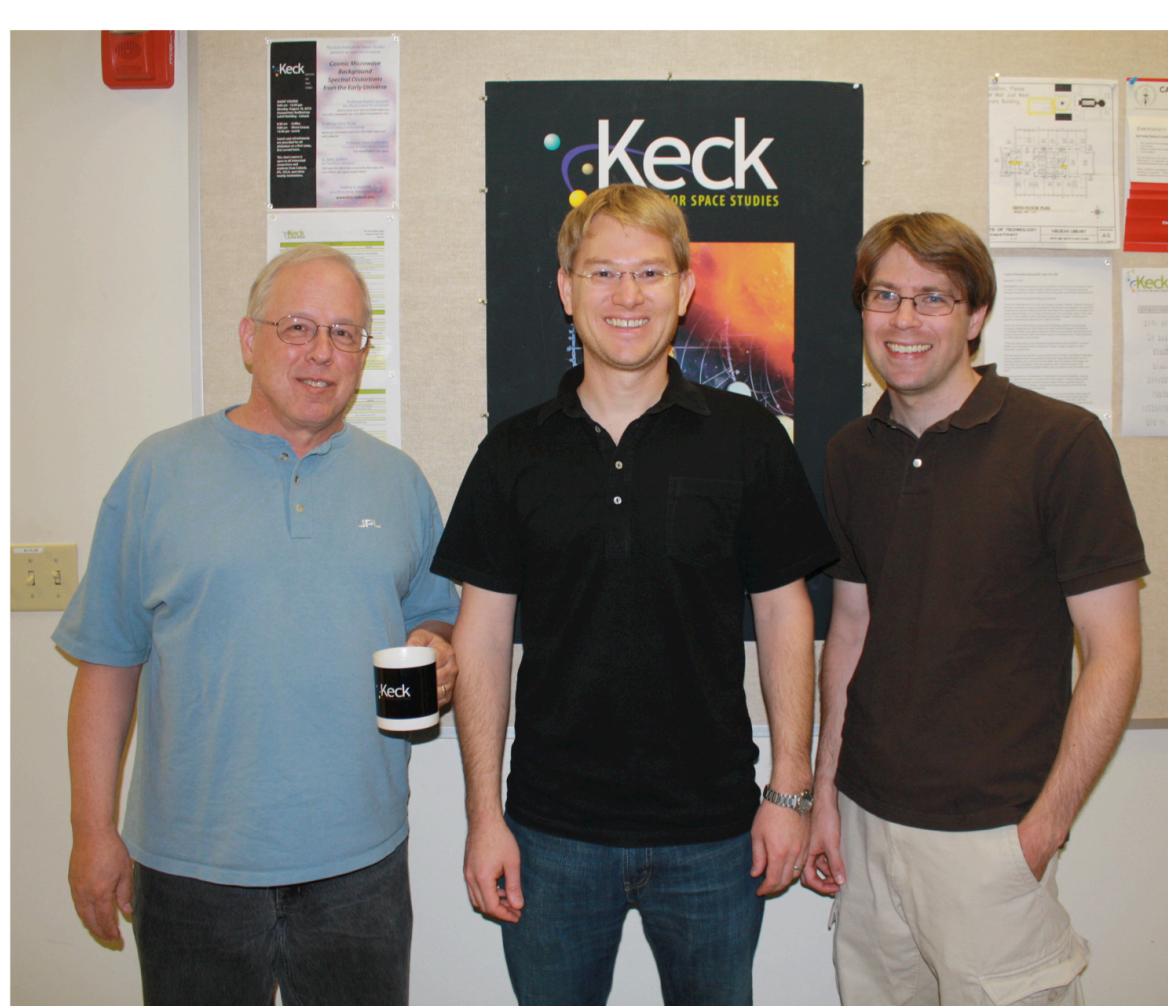


Summary of Keck Institute Workshop on the First Billion Years

Dayton Jones (JPL, Caltech), Judd Bowman (Arizona State U.), & Steve Furlanetto (UCLA)

Introduction

The Keck Institute for Space Studies, funded jointly by Caltech and JPL to develop concepts for future collaborative space missions, hosted a workshop on the First Billion Years during August 2010. The focus was on observational techniques to explore the cosmic Dark Ages and the Epoch of Reionization. All wavelength regions and many instrumental ideas were considered by the international participants, with a goal of defining the most scientifically, technically, and financially viable concepts.



Workshop organizers:
Dayton Jones (JPL), Judd Bowman (Caltech,
now at ASU), Steve Furlanetto (UCLA)



Workshop
participants

Concepts Discussed

Monopole (spectral distortion) experiments:

- Thermal spectrum distorted by energy injection and atomic lines
- Annihilation, decaying particles
- Coulomb, Compton scattering
- Hydrogen and Helium recombination lines
- Monopole may be the only thing we can measure from Dark Ages

Imaging (anisotropy) experiments:

- Redshifted HI (monopole → statistics → mapping)
- Look for near-term ground based experiment opportunities
- High-z CO intensity mapping (cross-correlate CO 2-1 and HI maps)
- Recombination line mapping

Preliminary Conclusions

Sequence of possible experiments and missions:

1. **Near-term foreground characterization experiments.**
Deep spectroscopy of anomalous absorption against strong, high galactic latitude background radio sources to measure flatness of spectrum with ~ 1 MHz resolution.
2. **CO spectral/spatial mapping to cross-correlate with high-z HI.**
Large scale structure at $z > 6$. 3-D cross-correlation with 21-cm HI data from LOFAR and MWA. Both 15 and 30 GHz, 10 arcmin pixels, $10^\circ \times 10^\circ$ field of view, > 100 channels, $1 \mu\text{K}$ rms sensitivity.
3. **Recombination line experiment.**
Measure amplitudes and peak frequencies of spectral wiggles from H (and He) recombination at very high z . Instrumentation similar to CO mapping experiment.
4. **Space-based low frequency monopole experiments.**
Integrated spectrum below usable ground-based frequencies.
5. **Space mission using CO 3-2 at ~ 50 GHz or [C II] at ~ 200 GHz.**
Cross-correlation of HI and CO fluctuations; fluctuations $\sim 0.5 \mu\text{K}$.



Working hard on the first billion years ...

Part of this work was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

This research was supported in part by the W. M. Keck Institute for Space Studies.

The LUNAR consortium, headquartered at the University of Colorado, is funded by the NASA Lunar Science Institute (via Cooperative Agreement NNA09DB30A) to investigate concepts for astrophysical observatories on the Moon